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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: COMBINATION ROLL AND DIE COATING METHOD AND APPARATUS WITH IMPROVED DIE LIP
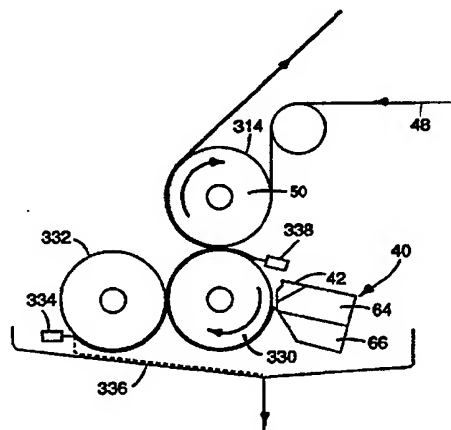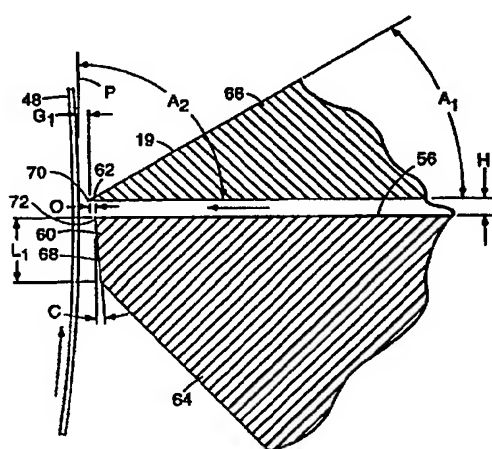
(57) Abstract

A die coating method and apparatus includes a die (40) having an upstream bar (64) with an upstream lip (60) and a downstream bar (66) with a downstream lip (62). The upstream lip is formed as a land (68) and the downstream lip is formed as a sharp edge (70). Coating fluid exists the die (40) from the slot to form a continuous coating bead between the upstream die lip, the downstream die lip, and the surface being coated. A metering roller (332) removes excess coating fluid from the coated web. The apparatus can include a roller (330) on which the coating fluid is initially coated and which contacts a web. A doctor blade (338) or a metering roller removes excess coating fluid from the roller.

COMBINATION ROLL AND DIE COATING METHOD AND APPARATUS
WITH IMPROVED DIE LIP

5

TECHNICAL FIELD

The present invention relates to coating methods. More particularly, the present invention relates to coating methods using a die.

10

BACKGROUND OF THE INVENTION

U.S. Patent No. 2,681,294 discloses a vacuum method for stabilizing the coating bead for direct extrusion and slide types of metered coating systems.

15 Such stabilization enhances the coating capability of these systems. However, these coating systems lack sufficient overall capability to provide the thin wet layers, even at very low liquid viscosities, required for some coated products.

20 U.S. Patent No. 4,445,458 discloses an extrusion type bead-coating die with a beveled draw-down surface to impose a boundary force on the downstream side of the coating bead and to reduce the amount of vacuum necessary to maintain the bead.

25 Reduction of the vacuum minimizes chatter defects and coating streaks. To improve coating quality, the obtuse angle of the beveled surface with respect to the slot axis, and the position along the slot axis of the bevel toward the moving web (overhang) and away

30 from the moving web (underhang) must be optimized. The optimization results in the high quality needed for coating photosensitive emulsions. However, the thin-layer performance capability needed for some coated products is lacking.

35 Figure 1 shows a known coating die 10 with a vacuum chamber 12 as part of a metered coating system. A coating liquid 14 is precisely supplied by a pump 16 to the die 10 for application to a moving web 18, supported by a backup roller 20. Coating liquid is

supplied through a channel 22 to a manifold 24 for
distribution through a slot 26 in the die and coating
onto the moving web 18.   As shown in Figure 2, the
coating liquid passes through the slot 26 and forms a

5   continuous coating bead 28 between the upstream die
lip 30 and the downstream die lip 32, and the web 18.
Dimensions f_1 and f_2, the width of the lips 30, 32
commonly range from 0.25 to 0.76 mm.   The vacuum
chamber 12 applies a vacuum upstream of the bead to

10   stabilize the bead.   While this configuration works
adequately in many situations, there is a need for a
die coating method which improves the performance of
known methods.

15   <u>SUMMARY OF THE INVENTION</u>
The present invention is a die coating
apparatus for coating fluid coating onto a surface.
The apparatus includes a die having an upstream bar
with an upstream lip and a downstream bar with a

20   downstream lip.   The upstream lip is formed as a land
and the downstream lip is formed as a sharp edge.   A
passageway runs through the die between the upstream
and downstream bars.   The passageway has a slot
defined by the upstream and downstream lips, and

25   coating fluid exits the die from the slot to form a
continuous coating bead between the upstream die lip,
the downstream die lip, and the surface being coated.
A metering roller removes excess coating fluid.   The
bead does not significantly move into the space

30   between the land and the surface to be coated even as
vacuum is increased.
Alternatively the apparatus can include a
roller on which the coating fluid is initially coated
and which contacts the web.   An excess coating fluid

35   remover removes excess coating fluid from the roller.
A die coats the coating fluid onto the roller.   The

remover can be a doctor blade or a metering roller and the coating liquid on the roller can be kiss transferred to the web.

5   A method of die coating according to the present invention includes passing coating fluid through a slot; improving coating performance by changing at least one of the relative orientations of the land and the sharp edge; removing excess coating fluid from the surface to be coated using a metering

10   roller; selecting the length of the land, the edge angle of the downstream bar, the die attack angle between the downstream bar surface of the coating slot and a tangent plane through a line on the surface to be coated parallel to, and directly opposite, the

15   sharp edge, and the coating gap distance between the sharp edge and the surface to be coated in combination with each other; and selecting the slot height, the overbite, and the convergence in combination with each other.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic, cross-sectional view of a known coating die.

Figure 2 is an enlarged cross-sectional view

25   of the slot and lip of the die of Figure 1.

Figure 3 is a cross-sectional view of an extrusion die of the present invention.

Figure 4 is an enlarged cross-sectional view of the slot and lip of the die of Figure 4.

30   Figure 5 is a cross-sectional view of the slot and lip similar to that of Figure 4.

Figure 6 is a cross-sectional view of an alternative vacuum chamber arrangement.

Figure 7 is a cross-sectional view of

35   another alternative vacuum chamber arrangement.

Figure 8 is a cross-sectional view of an alternative extrusion die of the present invention.

Figures 9a and 9b are enlarged cross-sectional views of the slot, face, and vacuum chamber

5   of the die of Figure 8.

Figures 10a and 10b are schematic views of the die of Figure 8.

Figure 11 shows coating test results which compare the performance of a known extrusion die and

10 an extrusion die of the present invention for a coating liquid of 1.8 centipoise viscosity.

Figure 12 shows comparative test results for a coating liquid of 2.7 centipoise viscosity.

Figure 13 is a collection of data from

15 coating tests.

Figure 14 is a graph of constant G/Tw lines for an extrusion coating die of the present invention for nine different coating liquids.

Figure 15 is a schematic view of a three

20 roll reverse roll coater using the die of the present invention.

Figure 16 is schematic view of a two roll reverse roll coater using the die of the present invention.

25 Figure 17 is a schematic view of a gravure coater using the die of the present invention.

Figure 18 is a two roll extrusion coater using the die of the present invention.

Figures 19a, 19b, and 19c are cross-

30 sectional views of a kiss coater using the die of the present invention.

Figures 20a, 20b, and 20c are cross-sectional views of a kiss coater using the die of the present invention.

35 Figure 20d is a cross-sectional view of a kiss coater using the die of Figure 19c.

DETAILED DESCRIPTION

This invention is a die coating method and
apparatus where the die includes a sharp edge and a
5   land which are positioned to improve and optimize
performance. The land is configured to match the
shape of the surface in the immediate area of coating
liquid application. The land can be curved to match a
web passing around a backup roller or the land can be
10   flat to match a free span of web between rollers.

Figure 3 shows the extrusion die 40 with a
vacuum chamber 42 of the present invention. Coating
liquid 14 is supplied by a pump 46 to the die 40 for
application to a moving web 48, supported by a backup
15   roller 50. Coating liquid is supplied through a
channel 52 to a manifold 54 for distribution through a
slot 56 and coating onto the moving web 48. As shown
in Figure 4, the coating liquid 14 passes through the
slot 56 and forms a continuous coating bead 58 among
20   the upstream die lip 60, the downstream die lip 62,
and the web 48. The coating liquid can be one of
numerous liquids or other fluids. The upstream die
lip 60 is part of an upstream bar 64, and the
downstream die 62 lip is part of a downstream bar 66.
25   The height of the slot 56 can be controlled by a U-
shaped shim which can be made of brass or stainless
steel and which can be deckled. The vacuum chamber 42
applies vacuum upstream of the bead to stabilize the
coating bead.

30   As shown in Figure 5, the upstream lip 60 is
formed as a curved land 68 and the downstream lip 62
is formed as a sharp edge 70. This configuration
improves overall performance over that of known die-
type coaters. Improved performance means permitting
35   operating at increased web speeds and increased
coating gaps, operating with higher coating liquid

viscosities, and creating thinner wet coating layer
thicknesses.

The sharp edge 70 should be clean and free
of nicks and burrs, and should be straight within 1
5   micron in 25 cm of length. The edge radius should be
no greater than 10 microns. The radius of the curved
land 68 should be equal to the radius of the backup
roller 50 plus a minimal, and non-critical, 0.13 mm
allowance for coating gap and web thickness.
10   Alternatively, the radius of the curved land 68 can
exceed that of the backup roller 50 and shims can be
used to orient the land with respect to the web 48. A
given convergence C achieved by a land with the same
radius as the backup roller can be achieved by a land
15   with a larger radius than the backup roller by
manipulating the land with the shims.

Figure 5 also shows dimensions of geometric
operating parameters for single layer extrusion. The
length L_1 of the curved land 68 on the upstream bar 64
20   can range from 1.6 mm to 25.4 mm. The preferred
length L_1 is 12.7 mm. The edge angle A_1 of the
downstream bar 66 can range from 20° to 75°, and is
preferably 60°. The edge radius of the sharp edge 70
should be from about 2 microns to about 4 microns and
25   preferably less than 10 microns. The die attack angle
A_2 between the downstream bar 66 surface of the
coating slot 56 and the tangent plane P through a line
on the web 48 surface parallel to, and directly
opposite, the sharp edge 70 can range from 60° to 120°
30   and is preferably 90°-95°, such as 93°. The coating
gap G_1 is the perpendicular distance between the sharp
edge 70 and the web 48. (The coating gap G_1 is
measured at the sharp edge but is shown in some
Figures spaced from the sharp edge for drawing
35   clarity. Regardless of the location of G_1 in the

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drawings - and due to the curvature of the web the gap
increases as one moves away from the sharp edge - the
gap is measured at the sharp edge.)

     Slot height H can range from 0.076 mm to

5   3.175 mm. Overbite O is a positioning of the sharp
edge 70 of the downstream bar 66, with respect to the
downstream edge 72 of the curved land 68 on the
upstream bar 64, in a direction toward the web 48.
Overbite also can be viewed as a retraction of the

10 downstream edge 72 of the curved land 68 away from the
web 48, with respect to the sharp edge 70, for any
given coating gap G_1. Overbite can range from 0 mm to
0.51 mm, and the settings at opposite ends of the die
slot should be within 2.5 microns of each other. A

15 precision mounting system for this coating system is
required, for example to accomplish precise overbite
uniformity. Convergence C is a counterclockwise, as
shown in Figure 5, angular positioning of the curved
land 68 away from a location parallel to (or

20 concentric with) the web 48, with the downstream edge
72 being the center of rotation. Convergence can
range from 0° to 2.29°, and the settings at opposite
ends of the die slot should be within 0.023° of each
other. The slot height, overbite, and convergence, as

25 well as the fluid properties such as viscosity affect
the performance of the die coating apparatus and
method.

     From an overall performance standpoint, for
liquids within the viscosity range of 1,000 centipoise

30 and below, it is preferred that the slot height be
0.18 mm, the overbite be 0.076 mm, and the convergence
be 0.57°. Performance levels using other slot heights
can be nearly the same. Performance advantages can
also be found at viscosities above 1,000 centipoise.

Holding convergence at 0.57°, some other optimum slot
height and overbite combinations are as follows:

	Slot Height	Overbite
5	0.15 mm	0.071 mm
	0.20 mm	0.082 mm
	0.31 mm	0.100 mm
	0.51 mm	0.130 mm

10   In the liquid viscosity range noted above, and for any
given convergence value, the optimum overbite value
appears to be directly proportional to the square root
of the slot height value. Similarly, for any given
slot height value, the optimum overbite value appears
15   to be inversely proportional to the square root of the
convergence value.

As shown in Figure 6, the vacuum chamber 42
can be an integral part of, or clamped to, the
upstream bar 64 to allow precise, repeatable vacuum
20   system gas flow. The vacuum chamber 42 is formed
using a vacuum bar 74 and can be connected through an
optional vacuum restrictor 76 and a vacuum manifold 78
to a vacuum source channel 80. A curved vacuum land
82 can be an integral part of the upstream bar 64, or
25   can be part of the vacuum bar 74, which is secured to
the upstream bar 64. The vacuum land 82 has the same
radius of curvature as the curved land 68. The curved
land 68 and the vacuum land 82 can be finish-ground
together so they are "in line" with each other. The
30   vacuum land 82 and the curved land 68 then have the
same convergence C with respect to the web 48.

The vacuum land gap G_2 is the distance
between the vacuum land 82 and the web 48 at the lower
edge of the vacuum land and is the sum total of the
35   coating gap G_1, the overbite O, and the displacement
caused by convergence C of the curved land 68.

(Regardless of the location of G_1 in the drawings the
gap is the perpendicular distance between the lower
edge of the vacuum land and the web.) When the vacuum
land gap G_2 is large, an excessive inrush of ambient
5   air to the vacuum chamber 42 occurs. Even though the
vacuum source may have sufficient capacity to
compensate and maintain the specified vacuum pressure
level at the vacuum chamber 42, the inrush of air can
degrade coating performance.

10   In Figure 7, the vacuum land 82 is part of a
vacuum bar 74 which is attached to the upstream bar
64. During fabrication, the curved land 68 is
finished with the convergence C "ground in." The
vacuum bar 74 is then attached and the vacuum land 82
15   is finish ground, using a different grind center, such
that the vacuum land 82 is parallel to the web 48, and
the vacuum land gap G_2 is equal to the coating gap G_1
when the desired overbite value is set. The vacuum
land length L_2 may range from 6.35 mm to 25.4 mm. The
20   preferred length L_2 is 12.7 mm. This embodiment has
greater overall coating performance capability in
difficult coating situations than the embodiment of
Figure 6, but it is always finish ground for one
specific set of operating conditions. So, as coating
25   gap G_1 or overbite O are changed vacuum land gap G_2 may
move away from its optimum value.

           In Figures 8 and 9 the upstream bar 64 of
the die 40 is mounted on an upstream bar positioner
84, and the vacuum bar 74 is mounted on a vacuum bar
30   positioner 86. The curved land 68 on the upstream bar
64 and the vacuum land 82 on the vacuum bar 74 are not
connected directly to each other. The vacuum chamber
42 is connected to its vacuum source through the
vacuum bar 74 and the positioner 86. The mounting and
35   positioning for the vacuum bar 74 are separate from
those for the upstream bar 64. This improves

performance of the die and allows precise, repeatable
vacuum system gas flow. The robust configuration of
the vacuum bar system also aids in the improved
performance as compared with known systems. Also,

5   this configuration for the vacuum bar 74 could improve
performance of other known coaters, such as slot,
extrusion, and slide coaters. A flexible vacuum seal
strip 88 seals between the upstream bar 64 and the
vacuum bar 74.

10   The gap G_2 between the vacuum land 82 and
the web 48 is not affected by coating gap G_1, overbite
O, or convergence C changes, and may be held at its
optimum value continuously, during coating. The
vacuum land gap G_2 may be set within the range from

15   0.076 mm to 0.508 mm. The preferred value for the gap
G_2 is 0.15 mm. The preferred angular position for the
vacuum land 82 is parallel to the web 48.

          During coating, the vacuum level is adjusted
to produce the best quality coated layer. A typical

20   vacuum level, when coating a 2 centipoise coating
liquid at 6 microns wet layer thickness and 30.5 m/min
web speed, is 51 mm H_2O. Decreasing wet layer
thickness, increasing viscosity, or increasing web
speed could require higher vacuum levels exceeding 150

25   mm H_2O. Dies of this invention exhibit lower
satisfactory minimum vacuum levels and higher
satisfactory maximum vacuum levels than known systems,
and in some situations can operate with zero vacuum
where known systems cannot.

30   Figures 10a and 10b show some positioning
adjustments and the vacuum chamber closure. Overbite
adjustment translates the downstream bar 66 with
respect to the upstream bar 64 such that the sharp
edge 70 moves toward or away from the web 48 with

35   respect to the downstream edge 72 of the curved land
68. Adjusting convergence rotates the upstream bar 64

and the downstream bar 66 together around an axis
running through the downstream edge 72, such that the
curved land 68 moves from the position shown in Figure
10, away from parallel to the web 48, or back toward
5 parallel. Coating gap adjustment translates the
upstream bar 64 and the downstream bar 66 together to
change the distance between the sharp edge 70 and the
web 48, while the vacuum bar remains stationary on its
mount 86, and the vacuum seal strip 88 flexes to
10 prevent air leakage during adjustments. Air leakage
at the ends of the die into the vacuum chamber 42 is
minimized by end plates 90 attached to the ends of the
vacuum bar 74 which overlap the ends of the upstream
bar 64. The vacuum bar 74 is 0.10 mm to 0.15 mm
15 longer than the upstream bar 64, so, in a centered
condition, the clearance between each end plate 90 and
the upstream bar 64 will range from 0.050 mm to 0.075
mm.

   One unexpected operating characteristic has
20 been observed during coating. The bead does not move
significantly into the space between the curved land
68 and the moving web 48, even as vacuum is increased.
This allows using higher vacuum levels than is
possible with known extrusion coaters, and provides a
25 correspondingly higher performance level. Even where
little or no vacuum is required, the invention
exhibits improved performance over known systems.
That the bead does not move significantly into the
space between the curved land 68 and the web 48 also
30 means that the effect of "runout" in the backup roller
50 on downstream coating weight does not differ from
that for known extrusion coaters.

   Figure 11 graphs results of coating tests
which compare the performance of a known extrusion die
35 with an extrusion die of this invention. In the
tests, the 1.8 centipoise coating liquid containing an

organic solvent was applied to a plain polyester film
web. The performance criterion was minimum wet layer
thickness at four different coating gap levels for
each of the two coating systems, over the speed range

5　of 15 to 60 m/min. Curves A, B, C, and D use the
known, prior art die and were performed with coating
gaps of 0.254 mm, 0.203 mm, 0.152 mm, and 0.127 mm,
respectively. Curves E, F, G, and H use a die
according to this invention at the same respective

10　coating gaps. The lower wet thickness levels for this
invention, compared to the prior art die, are easily
visible. Figure 12 shows comparative test results for
a similar coating liquid of 2.7 centipoise viscosity,
at the same coating gaps. Once again, the performance

15　advantage for this invention is clearly visible.

Figure 13 is a collection of data from
coating tests where liquids at seven different
viscosities, and containing different organic
solvents, were applied to plain polyester film webs.

20　The results compare performance of the prior art
extrusion coater (PRIOR) and this invention (NEW).
The performance criteria are mixed. Performance
advantages for this invention can be found in web
speed (Vw), wet layer thickness (Tw), coating gap,

25　vacuum level, or a combination of these.

One measure of coater performance is the
ratio of coating gap to wet layer thickness (G/Tw),
for a particular coating liquid and web speed. Figure
14 shows a series of constant G/Tw lines and viscosity

30　values of an extrusion die of this invention, for nine
different coating liquids. The liquids were coated on
plain polyester film base at a web speed of 30.5
m/min. A few viscosity values appear to be out of
order, due to the effect of other coatability factors.

35　Four additional performance lines have been added
after calculating the G/Tw values for 30.5 m/min web

speed from Figures 11 and 12. From top to bottom, the
solid performance lines are the G/Tw for liquids of
2.7 centipoise and 1.8 centipoise coated by a known
extrusion die and the G/Tw for liquids of 2.7

5   centipoise and 1.8 centipoise coated by an extrusion
die of this invention. The lines for of this
invention represent greater G/Tw values than the lines
for of the prior art coating die. In addition, the
lines for this invention are close to being lines of

10   constant G/Tw, averaging 18.8 and 16.8, respectively.
The lines of the known coater show considerably more
G/Tw variation over their length. This invention has
a much improved operating characteristic for
maintaining a coating bead at low wet thickness

15   values, over known systems.
Coating dies of this invention can be used
as high performance liquid feed devices for roll and
kiss coaters. Figure 15 shows a three roll reverse
roll coater using an extrusion die 40 to feed coating

20   liquid 14 to a casting roller 330. Because the
surface of the casting roller 330 passes the die 40 in
a downward direction, the die 40 is inverted and the
vacuum chamber 42 is above the slot and the coating
bead. This does not affect coating performance. A

25   metering roller 332 removes excess coating liquid,
leaving a precise layer on the casting roller 330. A
doctor blade 334 removes the excess coating liquid
from the metering roller 332 and drops it into a
liquid return pan 336 for recirculation.

30   Meanwhile, a bead-splitting action transfers
part of the coating liquid from the casting roller 330
to the web 48 moving around the backup roller 50.
After the bead splits, a second doctor blade 338
cleans the remaining coating liquid from the casting

35   roller 330 and runs it into the recirculation pan 336.
Alternatively, the backup roller 50 can be rubber

covered so the casting roller 330 can contact the web
and transfer all of the coating liquid in this area to
the web. The second doctor blade 338 would then clean
any liquid from the casting roller 330 which is

5   outside of the web width.

Figure 16 shows a two roll reverse roll
coater using an extrusion die 40 to feed coating
liquid to the surface of the web 48 moving around the
backup roller 14, which is a wrapped casting roller.

10   The metering roller 332 removes excess coating liquid
from the surface of the web 48, leaving the desired,
precise wet coated layer. The doctor blade 334 cleans
the excess coating liquid from the metering roller 332
and runs it into the recirculation pan 336. Use of

15   this system in one example increased the vacuum window
from 5.08 mm to over 254 mm H_2O, and increased the
liquid feed coating gap from 0.10 mm to 0.36 mm,
thereby improving stability and practically
eliminating streaking.

20   Figure 17 shows a gravure coater using an
extrusion die 40 to feed coating liquid to the surface
of a knurled roller 340. The die 40 has its vacuum
chamber 42 above its coating slot. A doctor blade 342
removes excess coating liquid from the knurl pattern

25   so that the desired amount transfers to the web 48
moving around the rubber-covered backup roller 314.
The excess coating liquid recirculates through the pan
336. This method of feeding coating liquid to the
surface of a knurled roller can also be used for other

30   forms of gravure coating such as reverse, offset, and
differential.

Figure 18 shows a two roll extrusion coater
using an extrusion die 40 to feed coating liquid to
the surface of the casting roller 330, with stability

35   from the vacuum chamber 42. The layer of coating
liquid is thin and precise so that a metering roll is

not required. The bead split takes place directly to
the web 48 moving around the backup roller 314. A
doctor blade 338 removes the coating excess liquid
from the casting roller 330 and recirculates it

5   through the pan 336. Alternatively, the backup roller
50 can be rubber covered so the casting roller 330 can
contact the web and transfer all of the coating liquid
in this area to the web. The second doctor blade 338
would then clean any liquid from the casting roller

10   330 which is outside of the web width.
               Figure 19a shows a kiss coater where an
extrusion die 40 feeds coating liquid through a
manifold 54 and a slot 56 to a transfer roller 344
such as a spindle having a diameter ranging from 25.4

15   mm to 50.8 mm. The coating bead is stabilized by the
vacuum chamber 42. The coating liquid on the transfer
roller 344 is kiss transferred to form the coated
layer on the web 48. The small diameter transfer
roller 344 has a small kiss transfer area, and

20   improves web stability over that with a larger
transfer roller by reducing web flutter and cross
tension marks. The surface of the transfer roller 344
can be, for example, smooth, polished, medium grind,
grit blasted, or knurled.

25   Figure 19b shows a kiss coater where the
extrusion die 40 with a vacuum chamber 42 feeds
coating liquid to the surface of a kiss transfer
roller 344. The roller 344 has a larger diameter than
the spindle of Figure 19a. The coating liquid is kiss

30   transferred to form the coated layer on the web 48.
               Figure 19c shows a kiss coater where a slide
coating die 310 feeds coating liquid to the surface of
a kiss transfer roller 344. The coating liquid is
kiss transferred to form the coated layer on the web

35   48.

Figure 20a shows a kiss coater where a dual-layer extrusion die 100 feeds two coating liquids 116, 124 through channels 118, 126 to the surface of a spindle, such as a transfer roller 344 having a
5   diameter ranging from 25.4 mm to 50.8 mm. The two coating liquids on the transfer roller 344 are transferred to form two coated layers on the web 48.

Figure 20b shows a kiss coater where a dual-layer extrusion die 100 feeds coating liquid to a kiss
10   transfer roller. The roller 344 has a larger diameter than the roller of Figure 20a. Two coating liquids 116, 124 are fed through two separate manifolds and two separate slots to meet at the coating bead. The two coating liquids are transferred to the web forming
15   wet coated layers.

Figure 20c shows a kiss coater where a dual-layer extrusion die 100 feeds coating liquid to a kiss transfer roller 344. The two coating liquids 116, 124 are fed through two manifolds, but only one slot,
20   meeting inside the die. The two coating liquids on the surface of the transfer roller 344 are transferred to form the two coated layers on the web 48.

Figure 20d shows a kiss coater where a multiple layer coating version of the die 220 of
25   Figure 19c feeds four coating liquids onto the surface of the transfer roller 344. Four liquids 116, 124, 346, 348 are fed through the die 100, down slide surfaces 236 to form four layers on the surface of the transfer roller 344. These layers are transferred to
30   form four coated layers on the web 48.

CLAIMS

1.   A die coating apparatus for coating
fluid coating onto a web moving around a backup roller
5   comprising:
        a die 40 having an upstream bar 64 with an
upstream lip 60 and a downstream bar 66 with a
downstream lip 62, wherein the upstream lip is formed
as a land 68 and the downstream lip is formed as a
10   sharp edge 70;
        a passageway 52 running through the die
between the upstream and downstream bars 64, 66,
wherein the passageway comprises a slot 56 defined by
the upstream and downstream lips 60, 62, wherein
15   coating fluid exits the die from the slot to form a
continuous coating bead between the upstream die lip,
the downstream die lip, and a surface being coated;
and
        a metering roller 332 which removes excess
20   coating fluid from the surface being coated.

2.   A die coating apparatus for coating
fluid coating onto a web comprising:
        a roller 330 on which the coating fluid is
25   initially coated and which subsequently transfers the
coating fluid to the web;
        means 338 for removing excess coating fluid
from the roller wherein the removing means contacts
the roller 330 to remove excess coating fluid;
30   a die 40 for coating the coating fluid onto
the roller 330 and having an upstream bar 64 with an
upstream lip 60 and a downstream bar 66 with a
downstream lip 62, wherein the upstream lip is formed
as a land 68 and the downstream lip is formed as a
35   sharp edge 70; and

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a passageway 52 running through the die
between the upstream and downstream bars 64, 66,
wherein the passageway comprises a slot 56 defined by
the upstream and downstream lips 60, 62, wherein
5   coating fluid exits the die from the slot to form a
continuous coating bead between the upstream die lip,
the downstream die lip, and the surface being coated.

3.   The apparatus of claim 2 wherein the
10   removing means 338 comprises a doctor blade.

4.   The apparatus of claim 2 wherein the
removing means comprises a metering roller 332.

15   5.   The apparatus of claim 3 wherein the
coating liquid on the roller is kiss transferred to
the web 48.

6.   A method of die coating comprising:
20   passing coating fluid through a slot 56
defined by an upstream bar 64 with an upstream lip 60
and a downstream bar 66 with a downstream lip 62,
wherein the upstream lip is formed as a land 68 and
the downstream lip is formed as a sharp edge 70;
25   improving coating performance by changing
the orientation of one of the land 68 and the sharp
edge 70;
        removing excess coating fluid from the
surface to be coated using a metering roller 332 which
30   contacts the surface to be coated;
        selecting a length L of the land, an edge
angle A_1 of the downstream bar, a die attack angle A_2
between the downstream bar surface of the coating slot
and a tangent plane through a line on the surface to
35   be coated parallel to and directly opposite the sharp
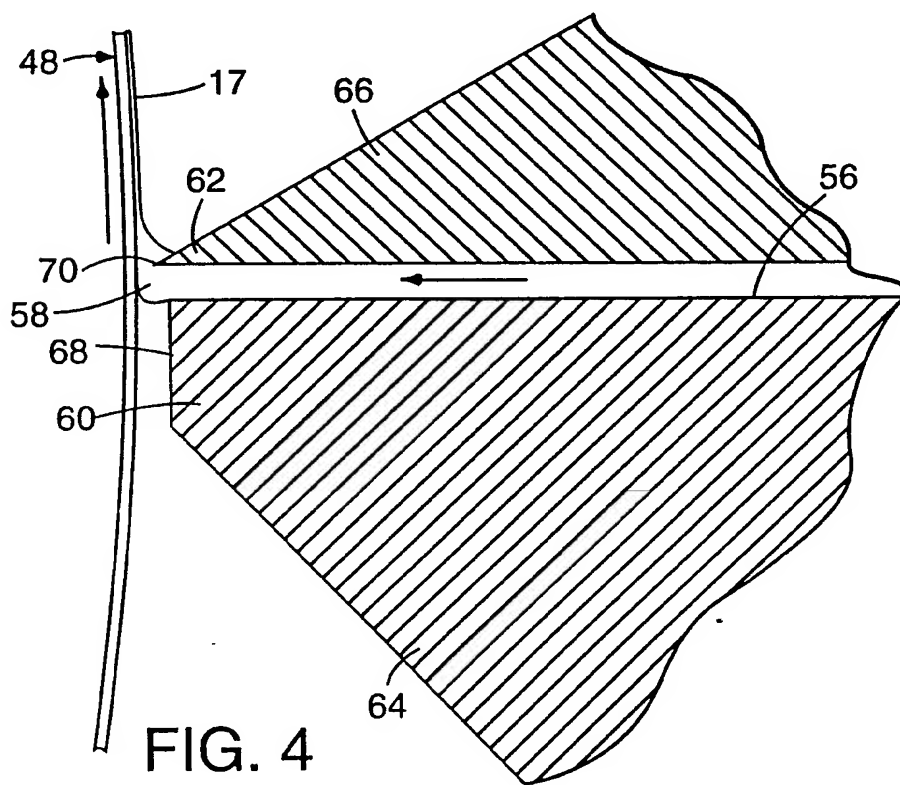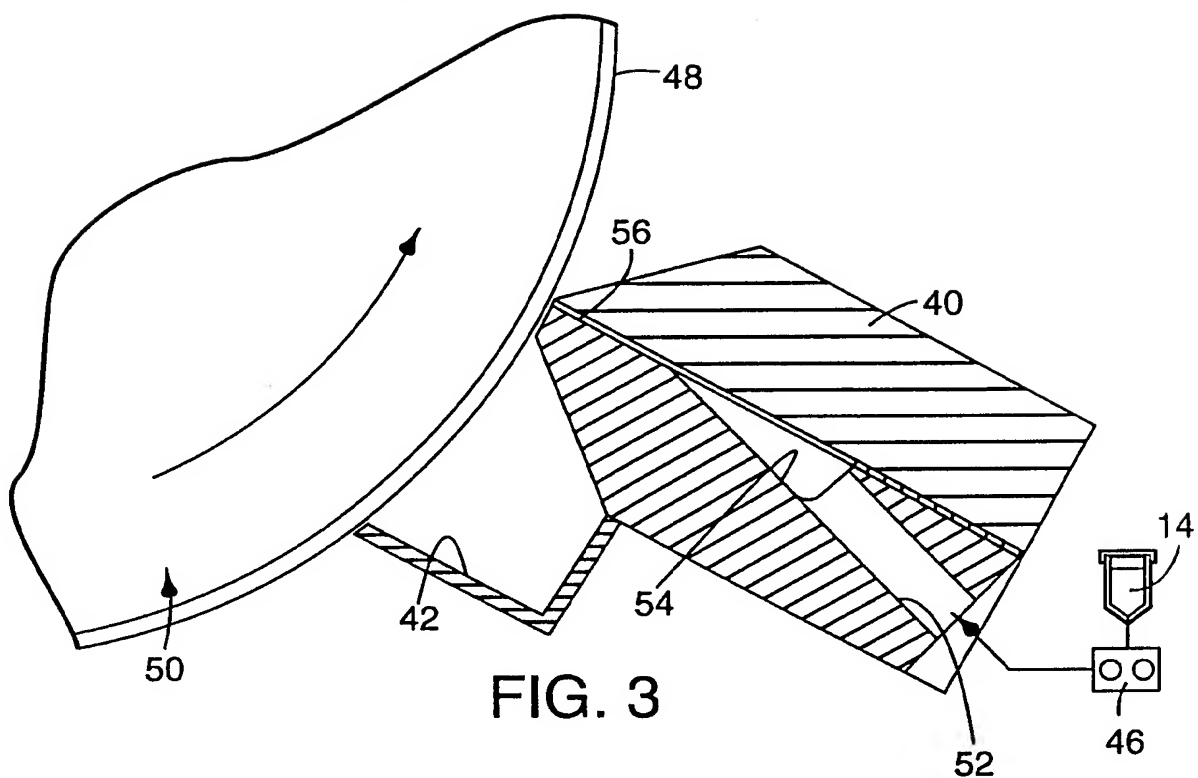edge, and a coating gap distance G between the sharp

edge and the surface to be coated in combination with each other; and
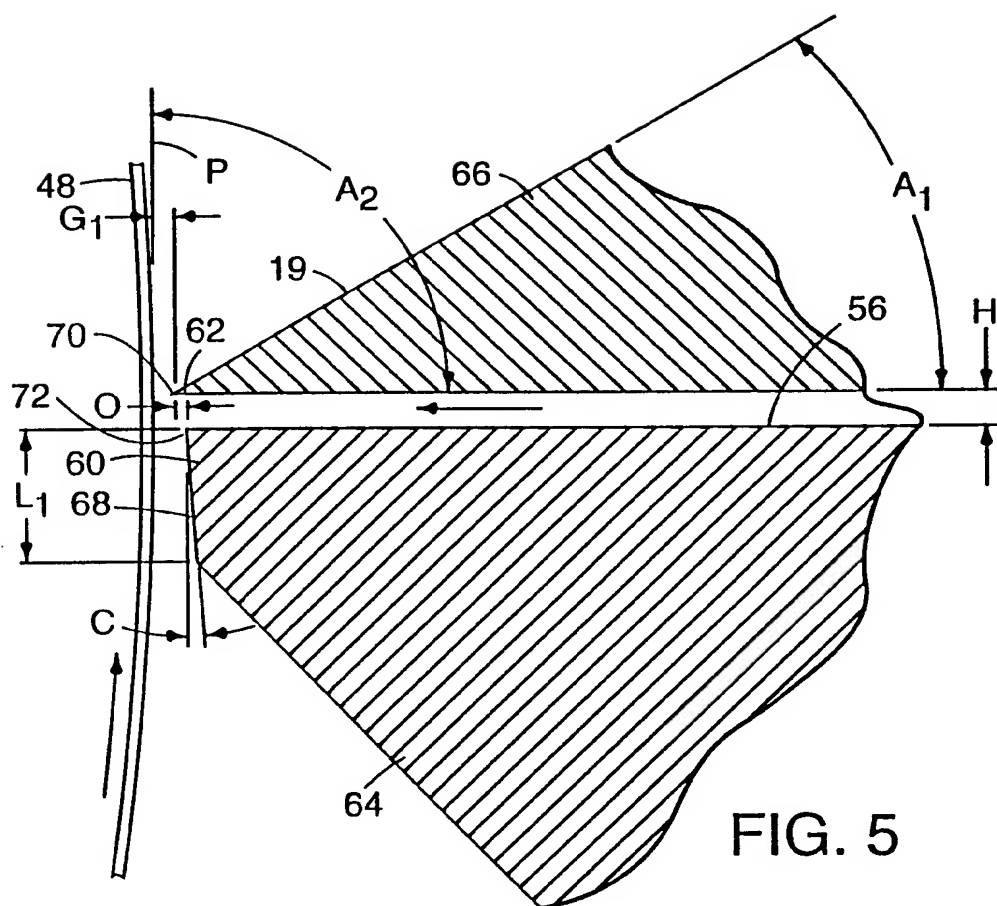
      selecting a slot height H, an overbite O, and a convergence C in combination with each other.

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      7.   The method of claim 6 further comprising the step of applying a vacuum upstream of a formed coating bead to stabilize the bead, wherein the bead does not significantly move into the space

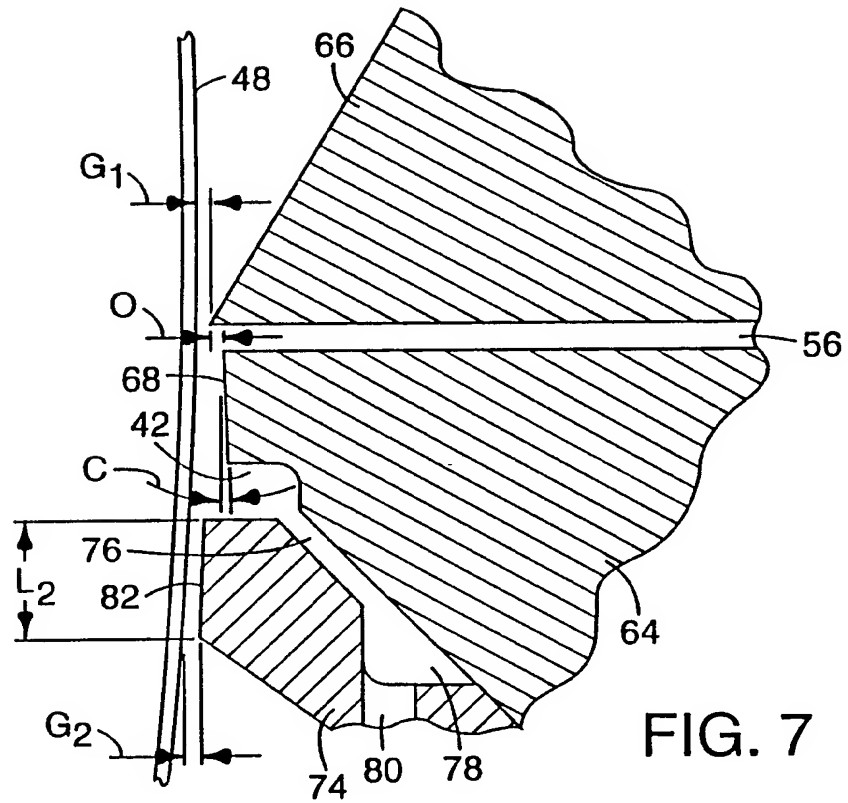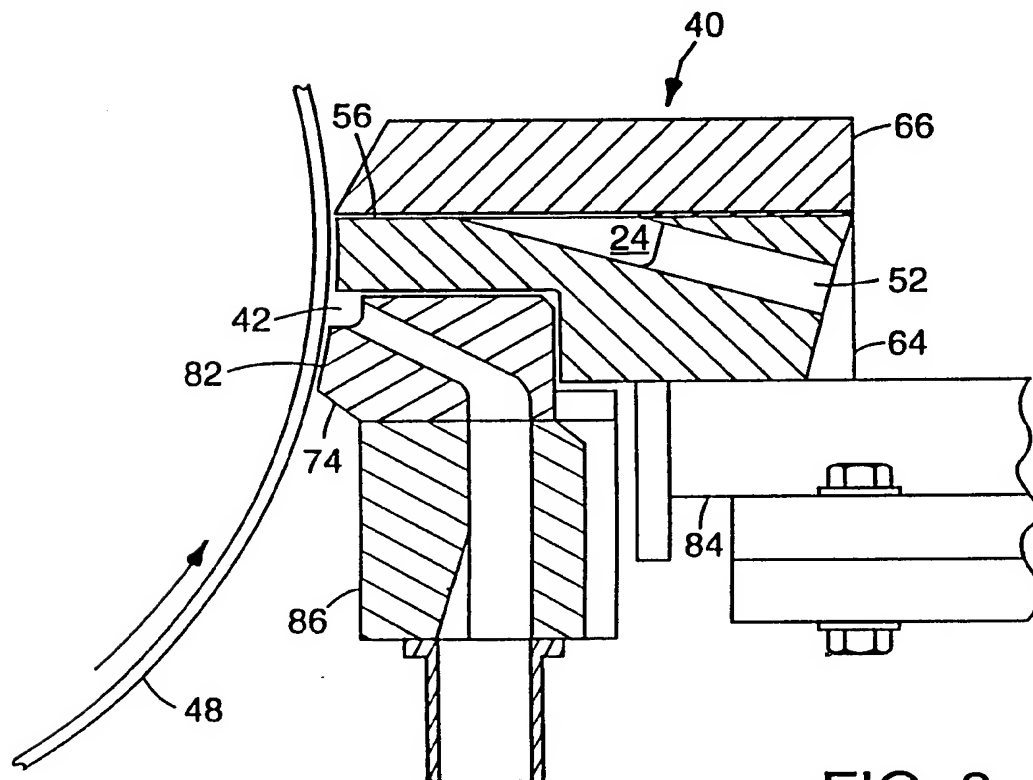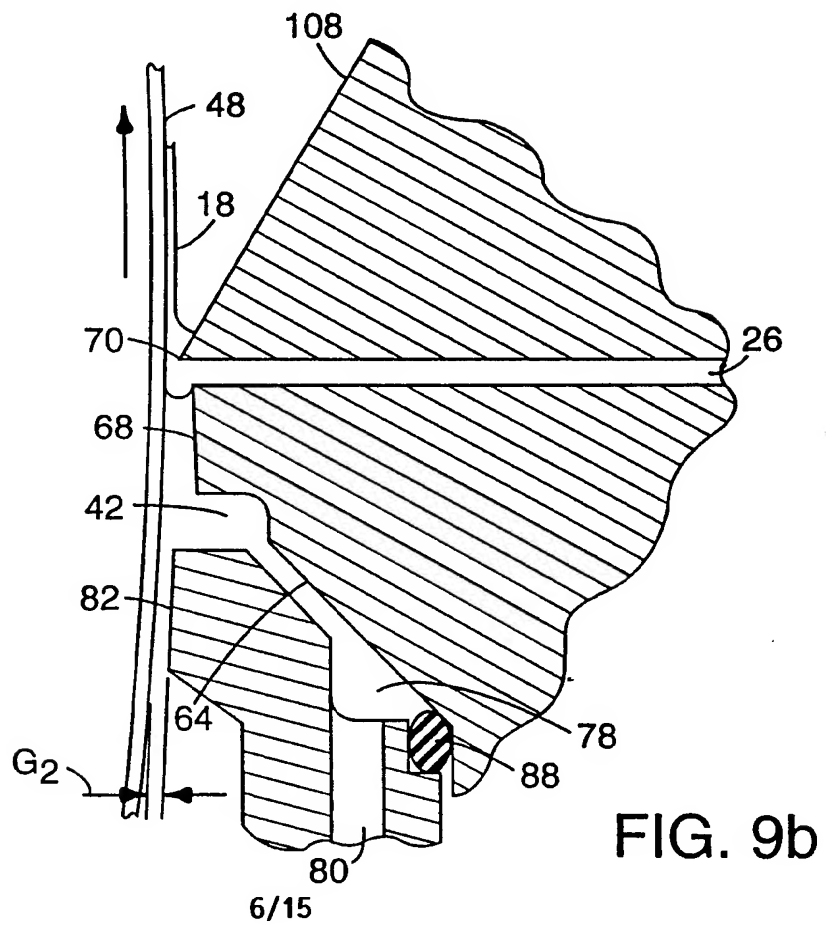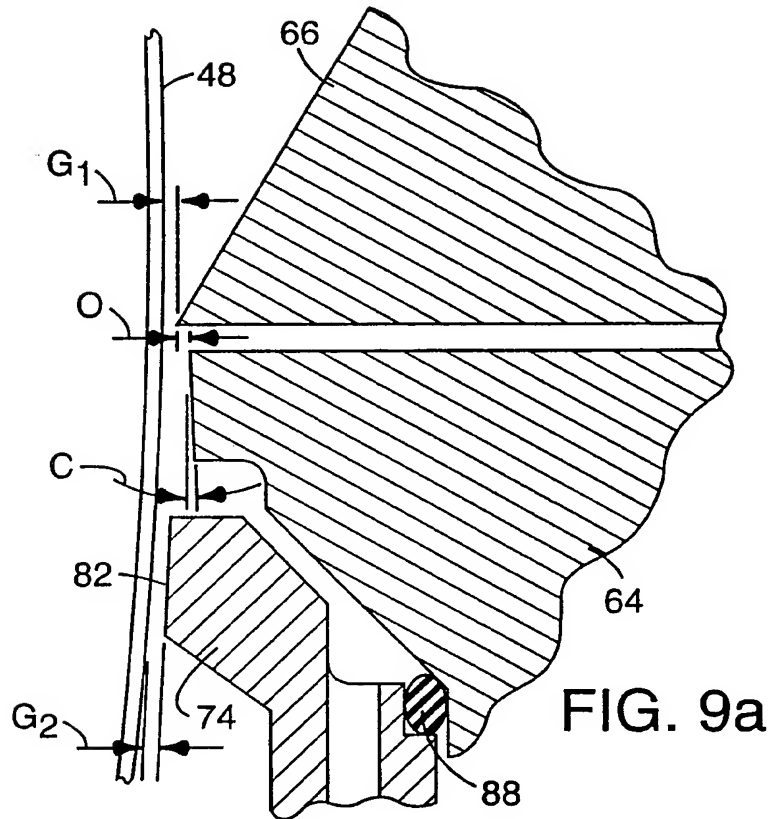10 between the land and the surface to be coated even as vacuum is increased.

FIG. 1
PRIOR ART

FIG. 2
PRIOR ART

FIG. 3

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FIG. 4

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FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIG. 9a

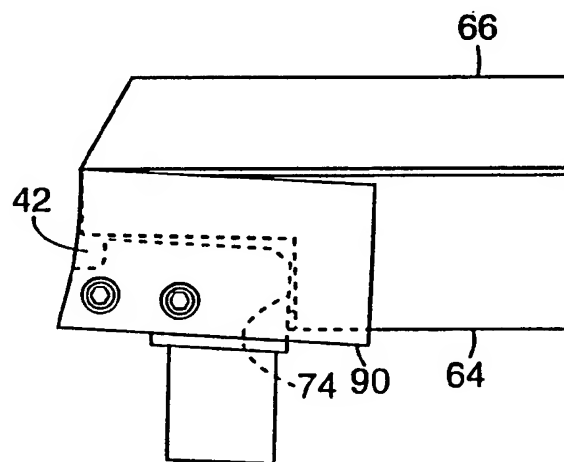FIG. 9b

FIG. 10a

FIG. 10b
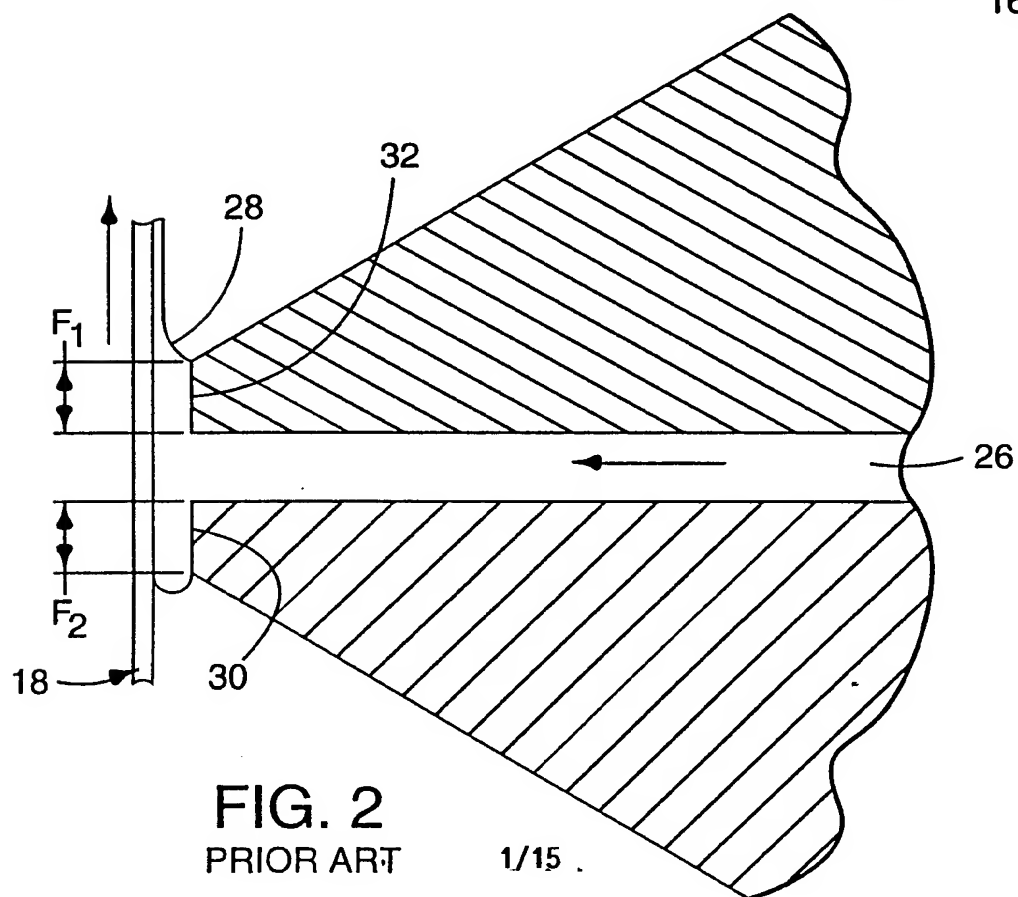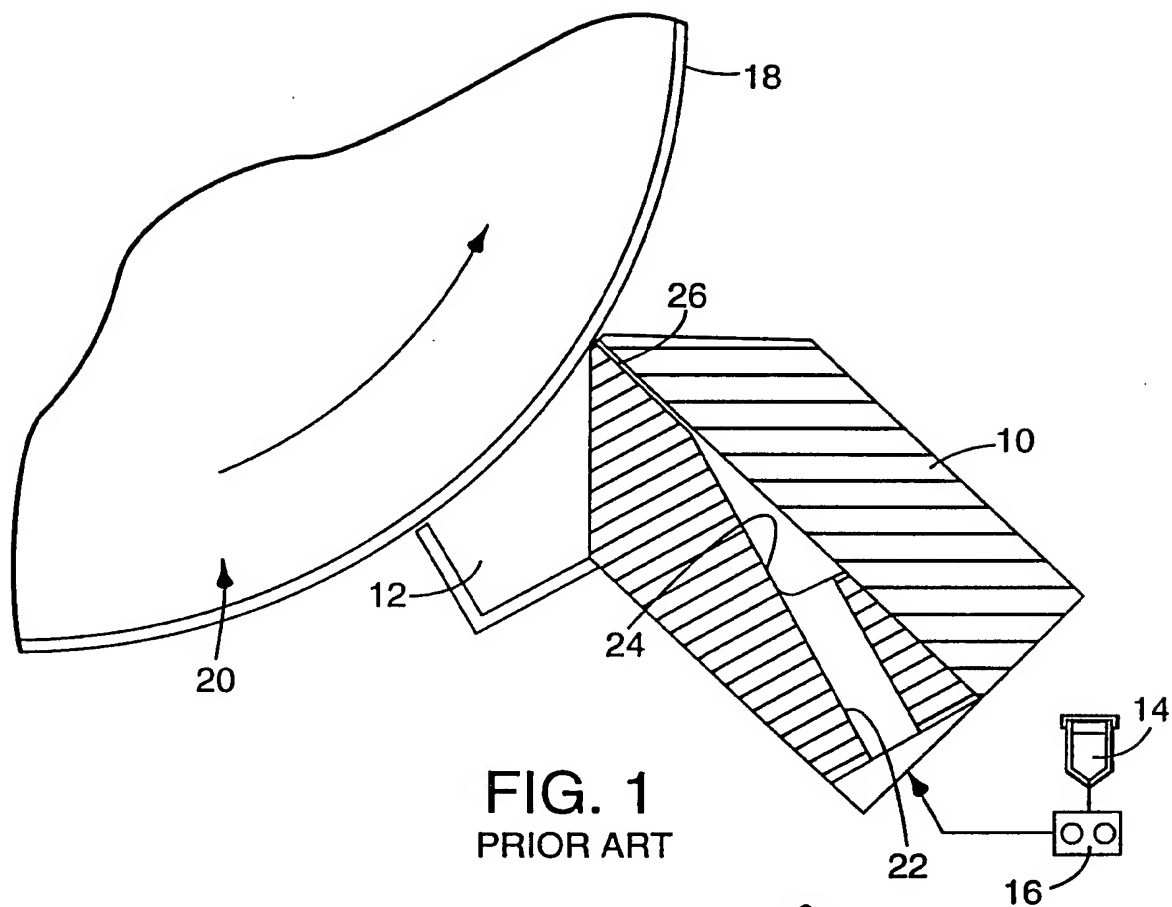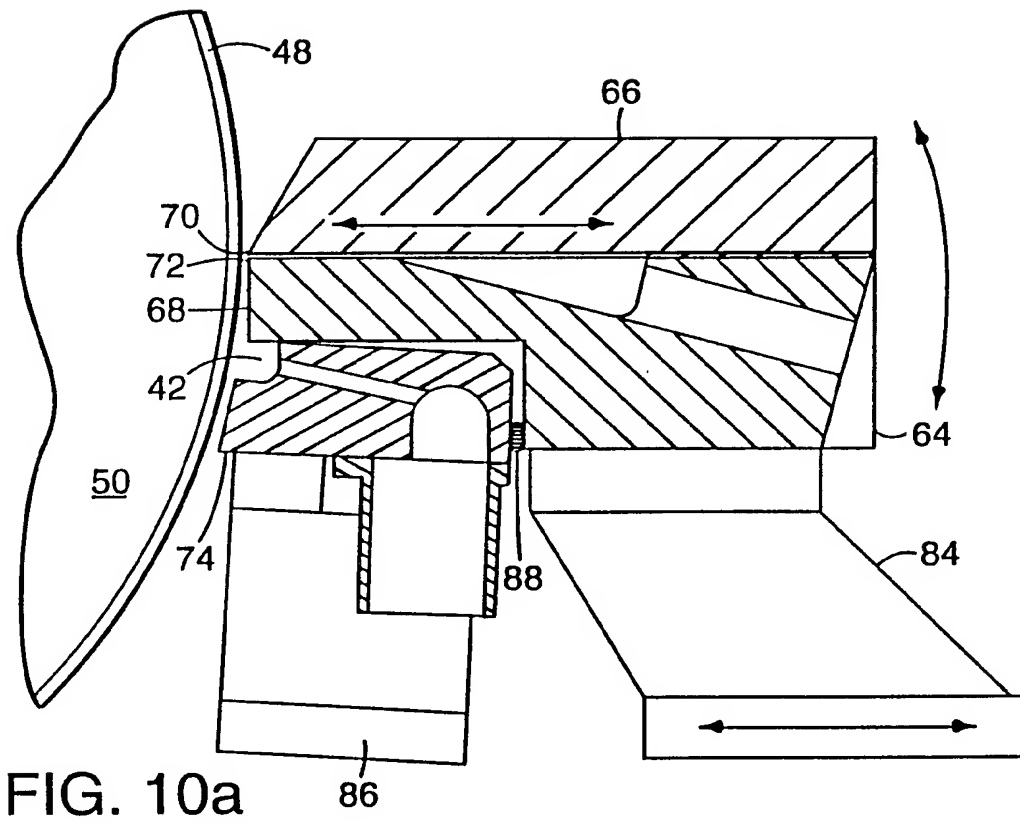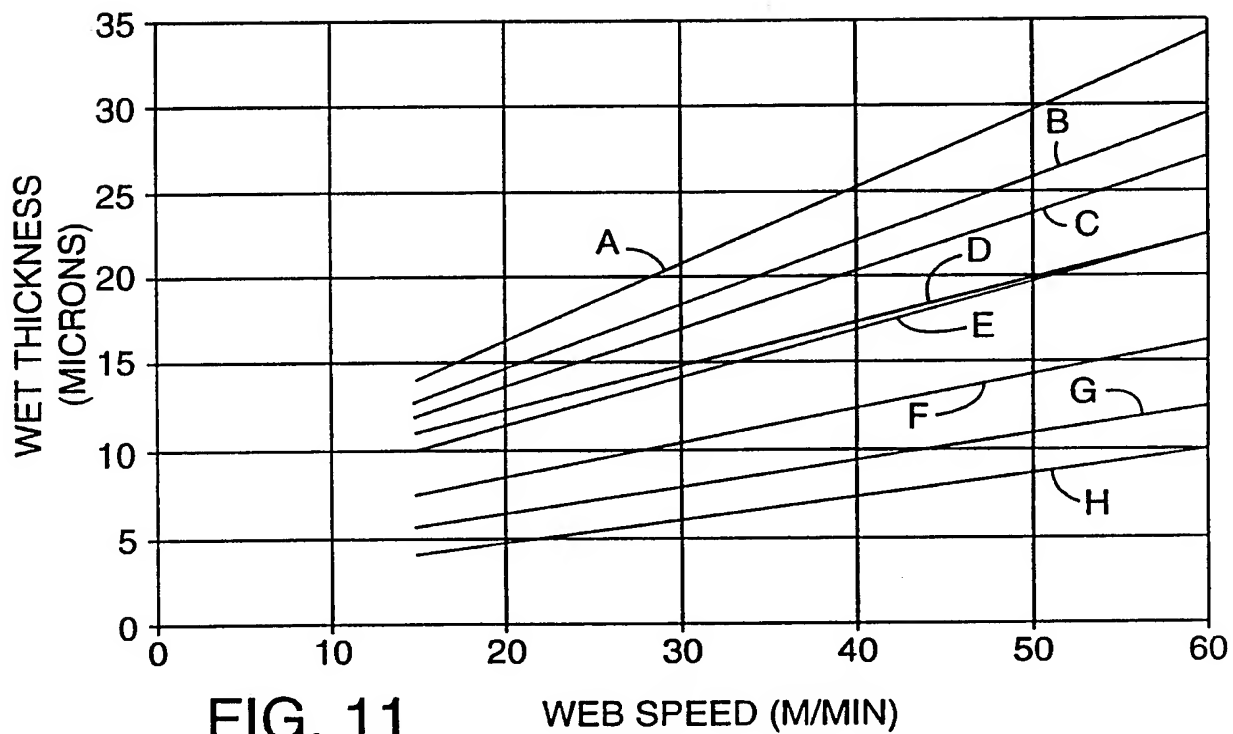
FIG. 11   WEB SPEED (M/MIN)
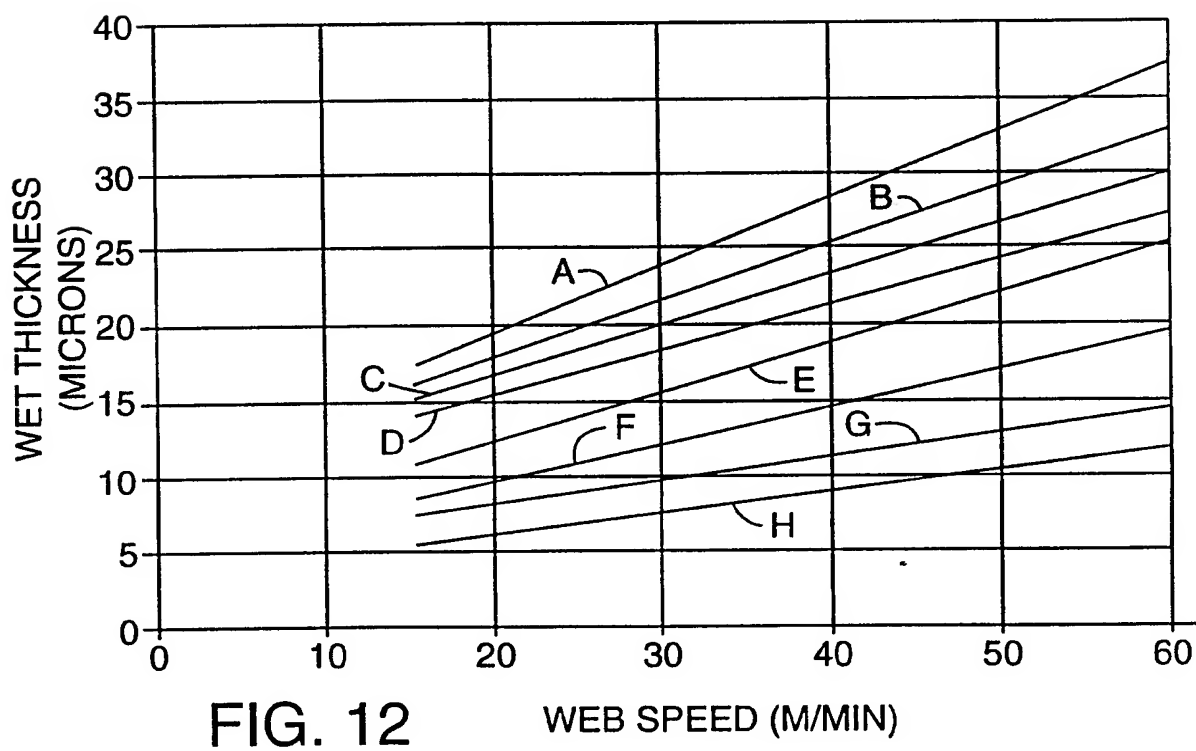
FIG. 12   WEB SPEED (M/MIN)

VIS (CPS)	Vw (M/MIN)		Tw (MICRONS)		CTG GAP (MM)		VAC (MM H2O)	
	PRIOR	NEW	PRIOR	NEW	PRIOR	NEW	PRIOR	NEW
37.6	9.1		22.2		0.076		190.5	
37.6		18.3		15.4		0.076		96.5
37.6		24.4		15.4		0.076		101.6
39.5	18.3	18.3	42	31	0.076	0.124	132.1	43.2
39.5	36.6	36.6	47.2	31	0.076	0.099	165.1	93.9
47	30.5	30.5	45.7	45.7	0.102	0.254	109.2	5.1
131.4	18.3	18.3	62	62	0.102	0.264	66	0
131.4		38.1		62		0.305		0
140	12.2	12.2	33.8	23.1	0.076	0.081	101.6	104.1
158	9.1		46.5		0.076		76.2	
158		15.2		23.2		0.076		167.6
600	15.2	15.2	177.3	177.3	0.254	0.432	0	0
600	24.4	24.4	177.3	177.3	0.254	0.305	25.4	0

FIG. 13
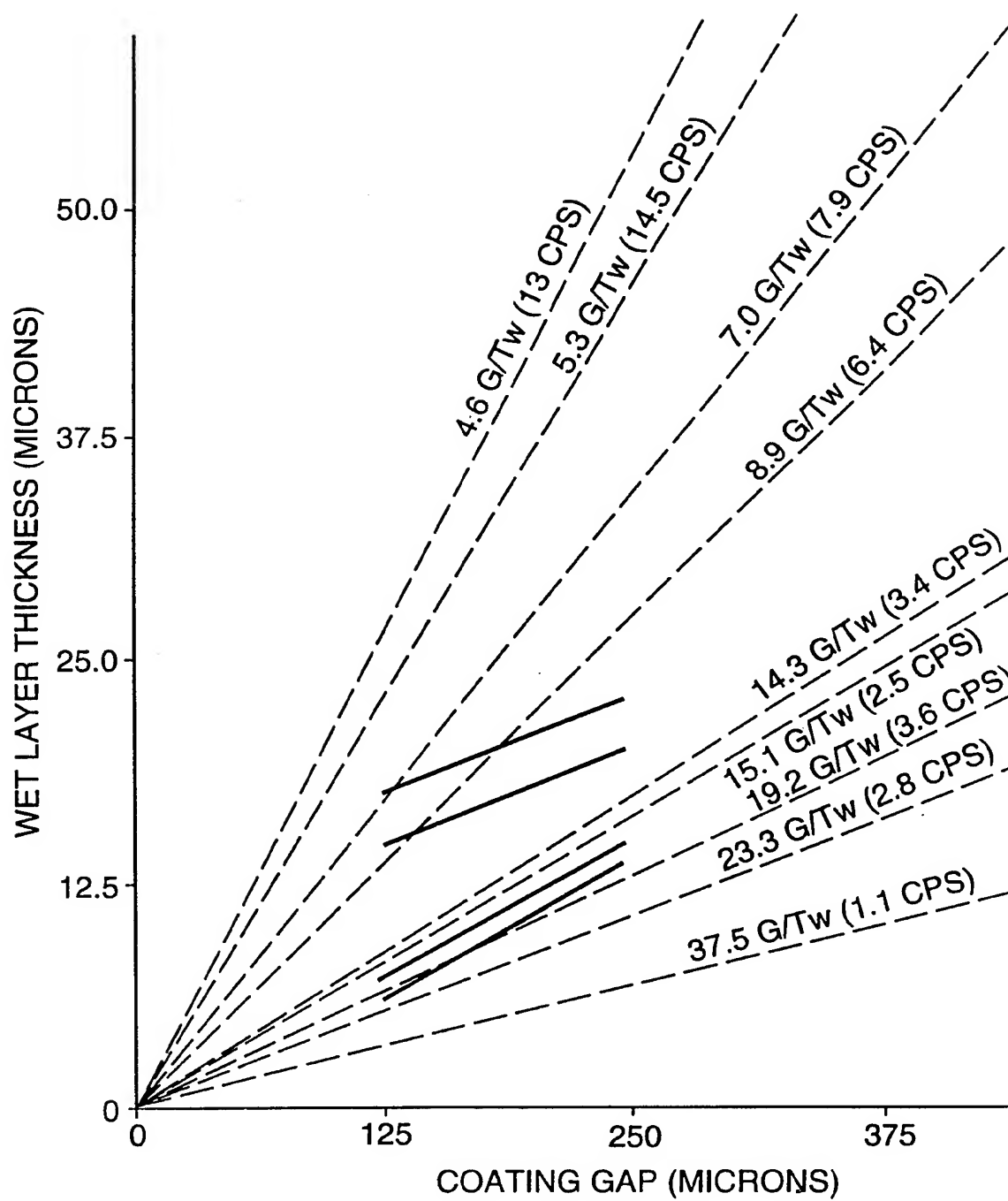
FIG. 14
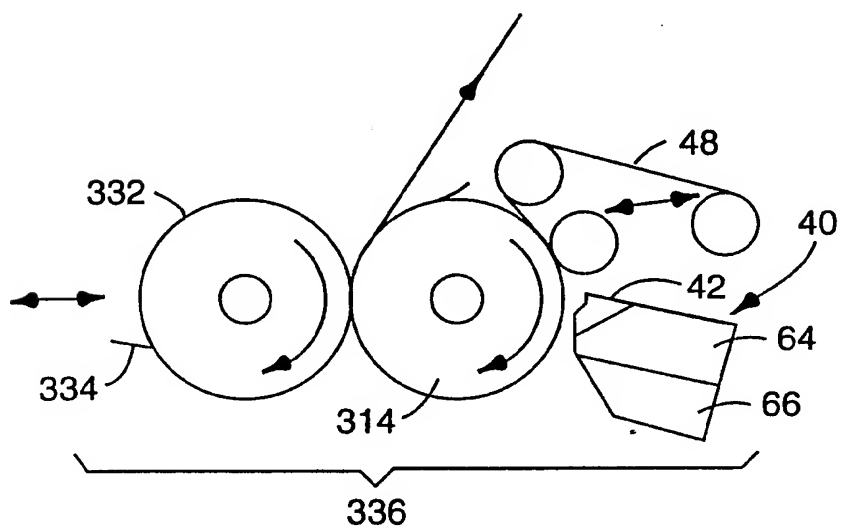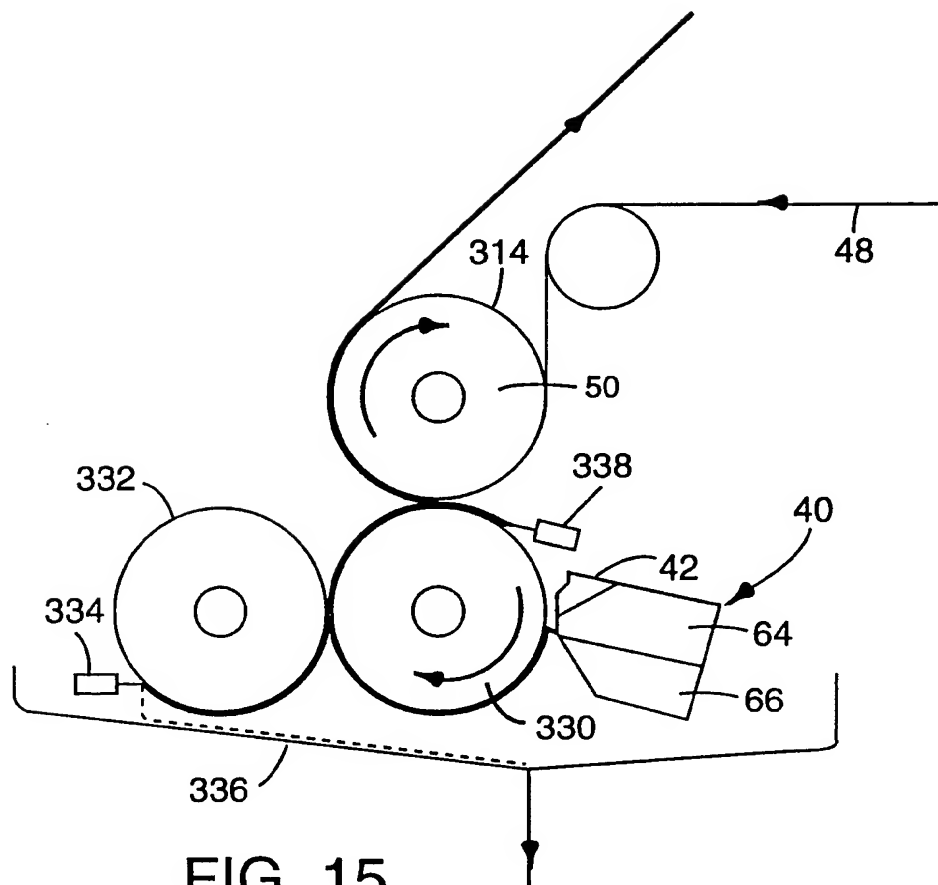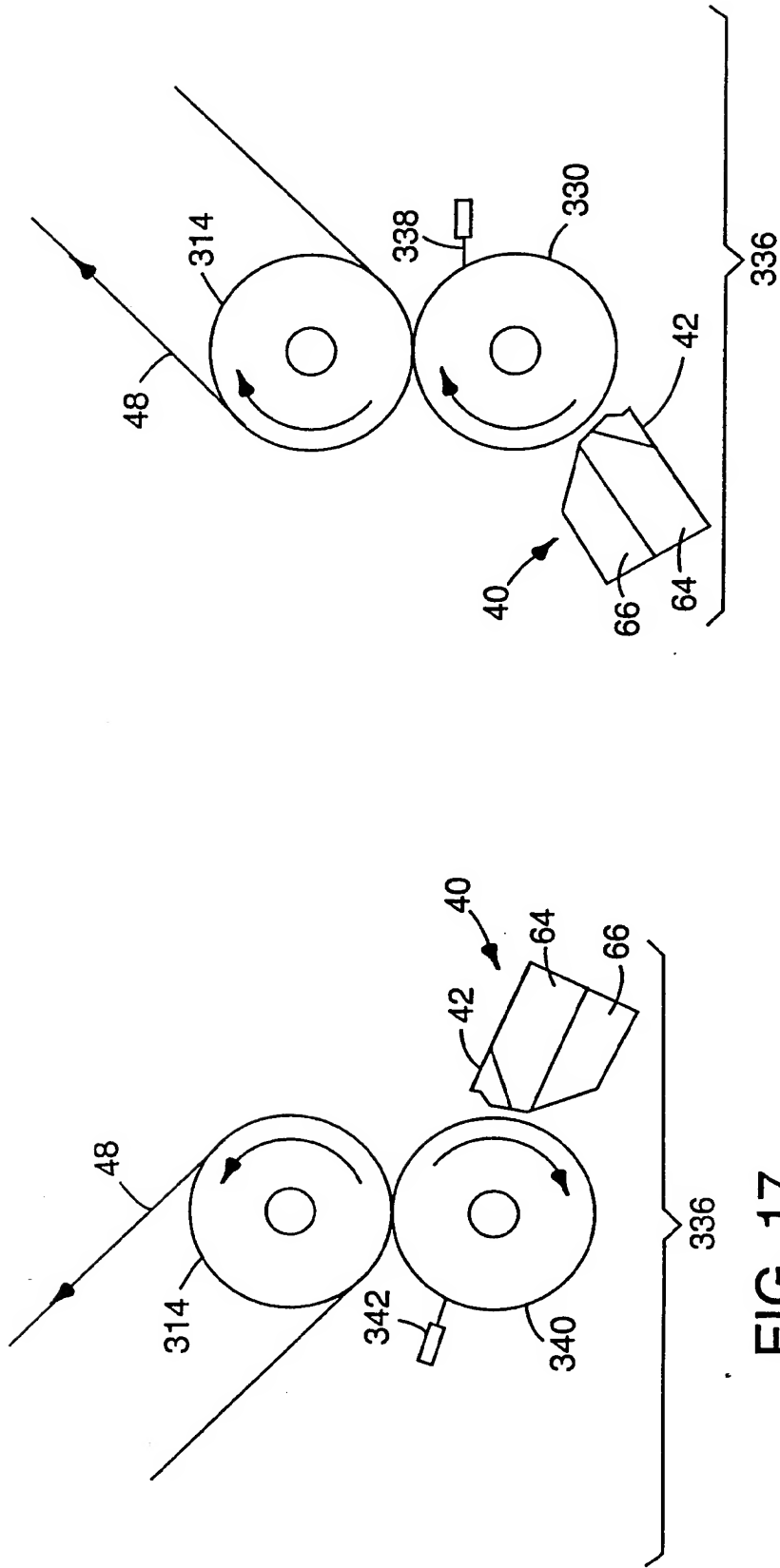
FIG. 15
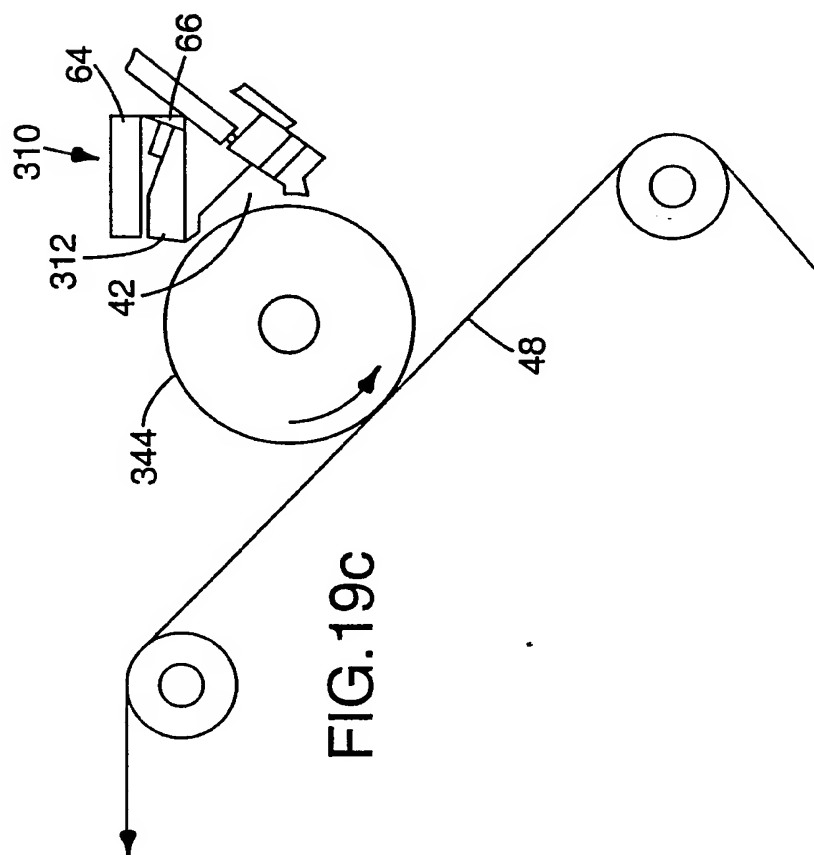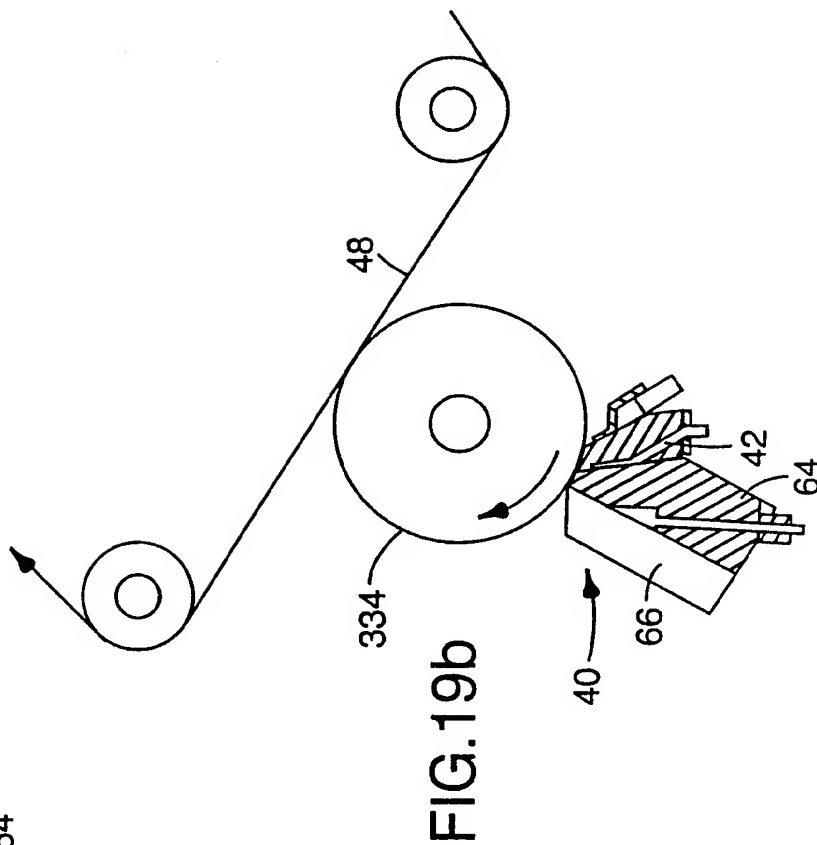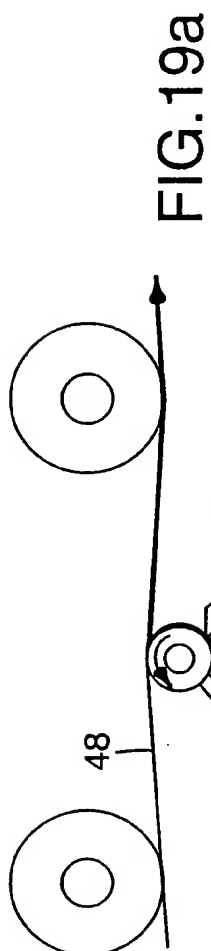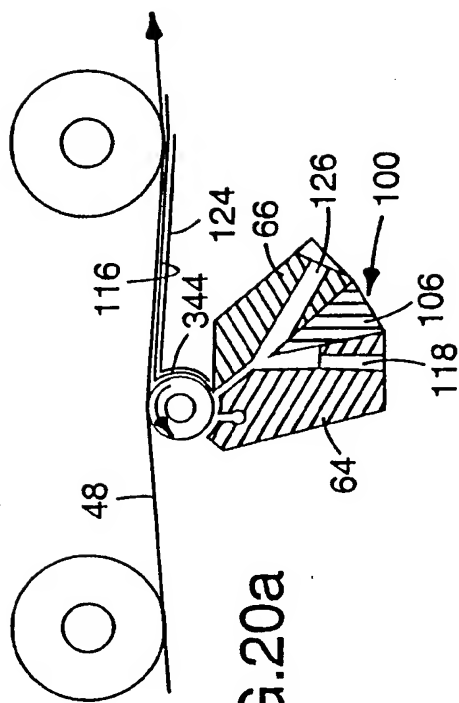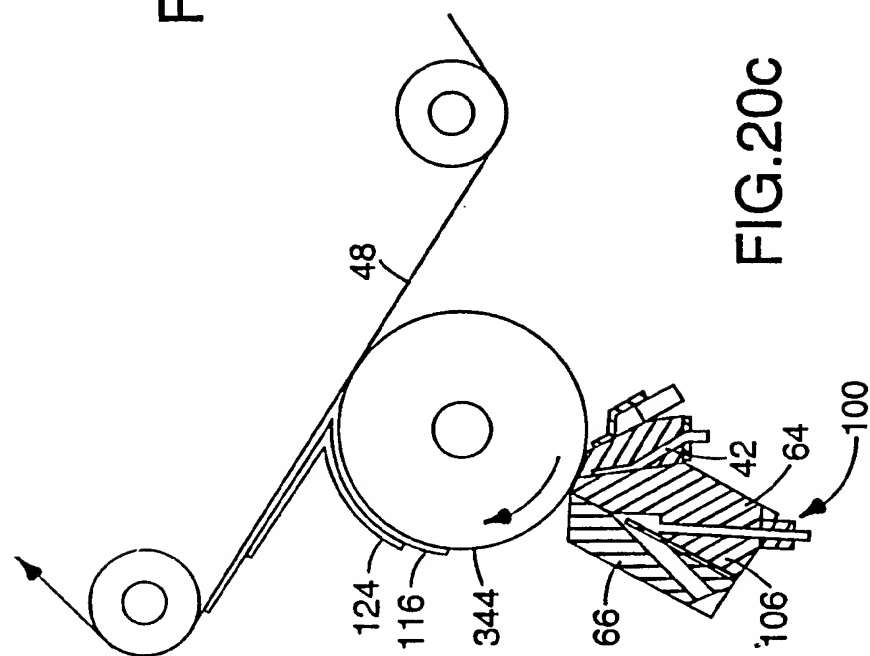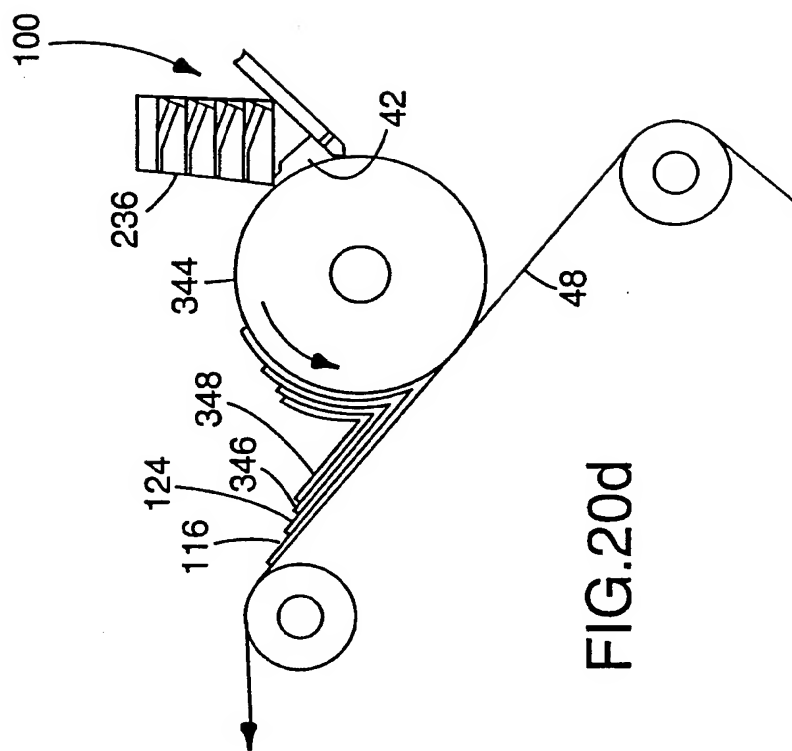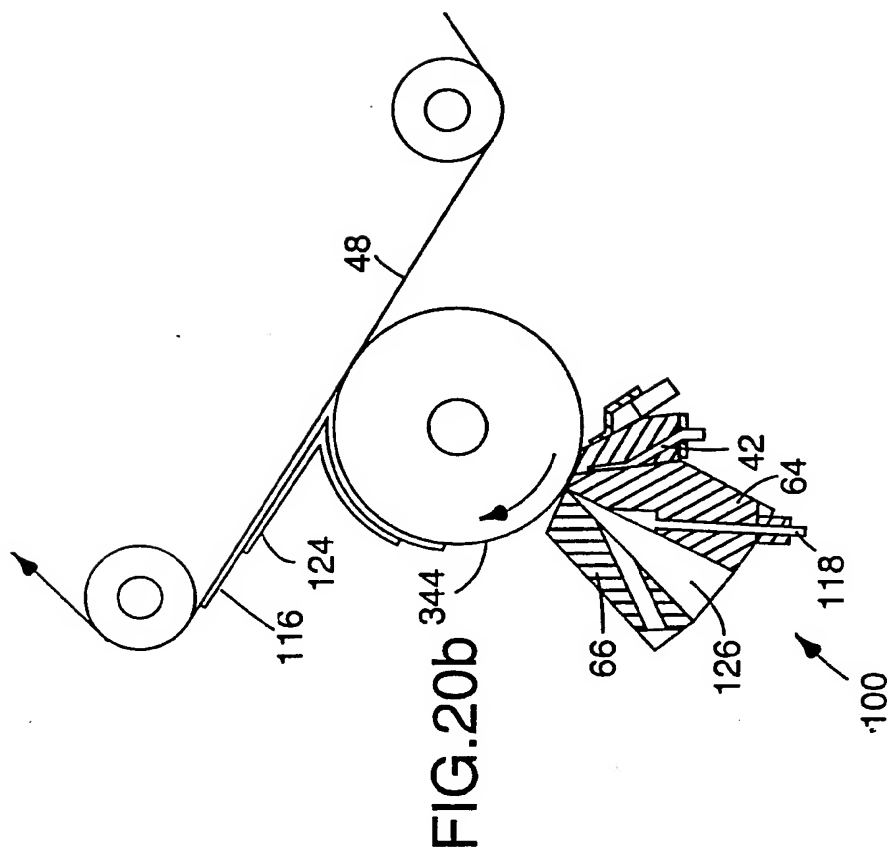
FIG. 16

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FIG. 18

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FIG. 17

FIG.19a

FIG.19b

FIG.19c

FIG.20a

FIG.20c

FIG.20d

FIG.20b

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6   B05C5/02   B05C1/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6   B05C   G03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 466 420 (ISHIKAWAJIMA-HARIMA JUKOGYO KK) 15 January 1992 see abstract see column 6, line 11 - line 19; figures ---	1,2,6
X	US,A,4 774 109 (HADZIMIHALIS ET AL.) 27 September 1988 see column 5, line 48 - line 54; figure 3 ---	1,2
X	EP,A,0 196 029 (UNION CARBIDE CORPORATION) 1 October 1986 see page 9, line 3 - page 10, line 22; figure 2 ---	1,2
X	DE,A,43 04 281 (FUJI PHOTO FILM CO., LTD) 2 September 1993 see page 4, line 22 - line 49; figures ---	1,2

-/--

X	Further documents are listed in the continuation of box C.		X	Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 June 1995	05.07.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Brévier, F

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page 1 of 2

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 332 840 (TANAKA ET AL.) 1 June 1982 see abstract; figures ---	1-4
A	EP,A,0 545 084 (KONICA CORPORATION) 9 June 1993 see figures ---	1,2,4
A	GB,A,1 192 515 (MAXIME GEORGE WILLYNK) 20 May 1970 see page 3, line 95 - page 4, line 13; figures ---	1,2,4
A	GB,A,2 040 738 (BELOIT CORPORATION) 3 September 1980 see abstract; figures ---	1,2,4
A	GB,A,1 098 434 (LOWE PAPER COMPANY) 10 January 1968 see page 1, line 52 - line 58; figures ---	1,2,4
A	RESEARCH DISCLOSURE, no.334, February 1992, EMSWORTH, GB pages 111 - 117, XP291212 'MANUFACTURING OF SOLVENT-BASED IMAGE-FORMING MATERIALS' see figure 1 ---	4,5
A	US,A,4 445 458 (O'BRIEN) 1 May 1984 cited in the application see figures -----	7

1

INTERNATIONAL SEARCH REPORT

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		DE-T-	3850111	19-01-95
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		NL-A-	6603760	10-10-66
US-A-4445458	01-05-84	NONE		

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